FEDERAL TRANSIT ADMINISTRATION

PROJECT MANAGEMENT OVERSIGHT PROGRAM

Contract No. DTFT60-04-D-00013
Project No. DC-27-5041
Task Order No. 10

CLIN 0005: Spot Report
Spot Report #1: Cost Validation Report

Grantee: City and County of Honolulu

Honolulu High-Capacity Transit Corridor

Cost Validation Report
May 2007

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LIST OF ACRONYMS

AA	Alternatives Analysis
BAH	Booz Allen Hamilton
BRT	Bus Rapid Transit
CBD	Central Business District
CIP	Cast-in-Place
COTR	Contracting Officer's Technical Representative
CSI	Construction Specification Institute, Inc.
DOT	Department of Transportation
DTS	Department of Transportation Services
EIS	Environmental Impact Statement
FD	Final Design
FMP	Fleet Management Plan
FTA	Federal Transit Administration
GET	General Excise Tax
HCTCP	Honolulu High-Capacity Transit Corridor Project
HRT	Heavy Rail Transit
ITS	Intelligent Transportation Systems
LPA	Locally Preferred Alternative
LRT	Light Rail Transit
MOS	Minimum Operating Segment
NEPA	National Environmental Policy Act
PBQD	Parsons Brinckerhoff Quade & Douglas, Inc.
PE	Preliminary Engineering
PMO	Project Management Oversight
PMOC	Project Management Oversight Contractor
PMP	Project Management Plan
PMSC	Project Management Support Consultant
ROD	Record-of-Decision
ROW	Right of Way
SCC	Standard Cost Categories
TOD	Transit Oriented Development
UH	University of Hawai'i
YOE	Year of Expenditure

I. EXECUTIVE SUMMARY

This report presents the results of analyses examining the reasonability of the project cost estimates for the Honolulu High-Capacity Transit Corridor Project (HCTCP). Specifically, this analysis focuses on the "New Starts" definition of that project as provided to Booz Allen Hamilton (BAH) by the grantee, the City and County of Honolulu (City). The primary objectives of these analyses are to:

1. Assess the reasonability of the current cost estimates;
2. Identify potential sources of cost risk; and,
3. Confirm absence of bias in cost estimation between the Fixed Guideway and Managed Lanes alternatives.

A. *Project Definition*

In December 2006, the City Council selected the Fixed Guideway alternative as the Locally Preferred Alternative (LPA) for the HCTCP. As currently defined, the New Starts segment of the Fixed Guideway is a twenty-mile fixed guideway alignment running from East Kapolei to Ala Moana Center, via Salt Lake Boulevard. This alignment consists primarily of aerial structure (17.79 miles) but also includes portions of at-grade exclusive (1.19 miles), below-grade cut & cover (0.28 miles), and retained cut (0.27 miles) right-of-way. The proposed investment also includes nineteen stations (17 aerial and 2 at-grade), sixty-six transit vehicles, and both administrative and maintenance facilities. At present, the specific modal technology for this project (e.g., light rail, heavy rail, or bus rapid transit) remains unspecified. However, the current project cost estimates, which include provisions for trackwork, train control systems, traction power supply and distribution, and light rail vehicles, assume light rail. The project is currently seeking entry into Preliminary Engineering (PE).

Exhibit I-1
New Start Project Definition Evaluated

Section	Alignments Being Considered	Alternatives	New Start Project
I. Kapolei to Ft Weaver Road	Saratoga Ave / North-South Rd	Alt 5	Partial
		Alt 6	Alternate
II. Ft Waever Rd to Aloha Stadium	Farrington Hwy / Kamehameha Hwy	Alt 1	Yes
III. Aloha Stadium to Middle St	Salt Lake Blvd	Alt 2	Yes
IV. Middle St. to Iwilei	Dillingham Blvd	Alt 3	Yes
V. Middle St. to Iwilei	Nimitz Hwy / Halekauwila St / Kapi'olani Blvd	Alt 8	Partial

B. *Cost Validation Process*

The cost validation exercise consists of the following main steps.

1. Top-Down Cost Validation: Conduct a top-down analysis of cost estimate reasonability; both in total and for each of the ten major Federal Transit Administration (FTA) Standard Cost Categories (SCC). This assessment includes:

a. Identification of any major SCC cost categories or category elements where the project cost estimates differ materially with prior U.S. transit project cost experience.
b. Where material cost differences are observed for specific cost elements, determination of the reasons for those differences.

2. Unit Cost Validation: Validate the unit costs used for a sample of primary project construction inputs such as concrete (e.g., forms, reinforcement, cast-in-place), steel (e.g., rebar), masonry, finishes, mechanical, and electrical – includes verification of both:
   a. Mainland-to-Honolulu regional cost adjustments, and,
   b. Comparison with unit costs for recent Honolulu/O‘ahu capital projects.

3. Cost Risk Review: Evaluate build-up of project cost estimates to for major SCC cost categories to:
   a. Determine whether cost estimates for sample of major cost items (such as elevated guideway and elevated stations) are consistent with current project descriptions / schematics / conceptual drawings
   b. Identify potential sources of cost risk based on detailed cost estimates

4. Managed Lanes Cost Assessment: Compare and contrast the grantee's cost build-up for the Managed Lanes and the Fixed Guideway alternatives, with the objective of identifying any bias or material differences in the cost build-up for the former.

The "top-down" analysis was conducted using FTA's Light Rail Capital Cost and Heavy Rail Capital Cost Databases, sources which document the as-built costs and project characteristics for close to fifty U.S. rail transit investments. These databases were used to identify where the cost of specific SCC cost elements for the Honolulu High-Capacity Transit Corridor Project may differ materially from past experience. The analysis then considered the reasons for these cost variations.

The unit cost validation was conducted by comparing the project's unit cost estimates for concrete, steel, and other primary materials with mainland costs for these same items, each adjusted to correct for regional cost differences (using sources such as RS Means, U.S. Army Corps of Engineers, Department of Defense, etc.). The unit cost validation also compared and contrasted project unit cost assumptions with actual unit costs from recently completed major capital projects in the Honolulu metro region.

The cost risk review compared the detailed cost build-up as provided for each alignment segment with project description and conceptual drawings to confirm that project costs are consistent with project characteristics as currently envisioned. This analysis also used the same detailed project cost build-up to identify cost elements that either may be missing from the current estimates or which may benefit from further refinement, to reduce cost risk.

C. *Key Findings – Top-Down Cost Validation*

A key challenge in conducting this cost reasonability analysis was the current lack of specificity in the project's modal definition. Given this lack of specificity, the current project costs were assessed using against the historical, as-built cost experiences of both light and heavy rail projects. Here the costs were compared primarily against prior light rail transit (LRT) costs, as Honolulu's cost estimates were developed assuming LRT, but also against heavy rail transit (HRT) costs were appropriate. In general, this latter approach proved most revealing as the project costs exhibit the cost characteristics of both light and heavy rail projects; with some elements having cost characteristics more similar to light rail (e.g., stations and vehicles) and others more similar to heavy rail (most notably aerial structure).

The cost validation analysis determined that the total project cost estimates are reasonable, falling marginally below (roughly $42 million, or less than 2%) the expected cost based on recent U.S. light and heavy rail projects. However, this low overall project cost variance is also the product of offsetting positive and negative cost variances across the eight cost categories recognized by the database cost model. Specifically, when the variance analysis is limited to "hard asset" costs alone, including track and structures, facilities, systems, stations, and vehicles, project cost estimates are found to marginally exceed the database predicted costs by roughly $95 million (or roughly 4.5%), again quite reasonable for a pre-PE project. In contrast, the combined project cost estimates for special conditions, right-of-way (ROW), and soft-costs were found to be roughly $135 million, or 10%, lower than expected based on prior project experience as represented in the FTA database. This level of cost variation from the "norm" suggests that these latter three cost categories may benefit from further refinement by Honolulu project staff.

Finally, the provisions for contingencies were found to be adequate and appropriate for a project in the pre-PE phase. Also, the assumed inflation rates used to adjust project costs from $2007 to $YOE (year of expenditure) were found to be reasonable but not conservative, based on recent cost inflation for construction projects nationally and local Honolulu consumer cost inflation.

D. *Key Findings – Unit Cost Validation*

The HCTCP cost estimate was developed by Parsons Brinckerhoff Quade & Douglas, Inc., the City's Alternatives Analysis (AA) Project Management Consultant. Overall, PBDQ's unit cost estimates for the Honolulu High-Capacity Transit Corridor Project were generally found to be similar to or within acceptable ranges to those derived from other existing sources, and hence should be considered reasonable at this stage of the project. A key exception here is the cost of cast-in-place (CIP) concrete (a key project input), where the project unit costs appear to be substantially lower than those found using either the RS Means or Naval Facility (NAVFAC) sources. It is possible that this finding may result from differences in the assumed CIP investment dimensions across these sources. Obtaining local and more recent concrete vendor quotes may help settle this issue."

Other key results included the following:

- Project unit costs, except those associated with cast-in-place (CIP) concrete, were typically greater than their RS Means counterparts, but within an acceptable range of +30%.

- NAVFAC's unit costs were generally greater by 20% to over 150% for some items, when compared to similar project unit costs. PBQD's listing of unit costs provides only minimal sizing parameters, while the NAVFAC Cost Data Book provides more specificity in terms of sizing, dimensions, and more discrete descriptions of the costs items.

- PBQD's unit costs were generally within the low-high ranges established by recent Hawaii Department of Transportation (DOT) bid tabulations for highway construction on the island.

- Given the recent price volatility in construction materials, current Honolulu market pricing for steel, asphalt, and concrete elements should be obtained to confirm any variances with the respective unit costs used in the PBQD estimate. Sources of such data can include contractor quotations and more current Hawaii DOT bid tabulations.

- Costs for heavy electrical installation/heavy traction power items given in the PBQD estimate could not be compared since no similar items were found in the RS Means, NAVFAC, and Tabulation of Bids reference sources.

E. *Key Findings – Cost Risk Analysis*

The cost risk review identified cost elements that either may be missing from the current estimates or which may benefit from further refinement, to reduce cost risk. Following are some of those items that may pose real cost risks to the project, and hence, which deserve further attention during PE.

<u>Utility Relocation Costs</u>

- <u>Underground Utilities Not Fully Reviewed Since 1991:</u> The last comprehensive utility assessment for buried utilities was performed in 1991 and consisted largely of a review of city utility maps. The current estimate by PBQD consists of updated relocation costs applied to the 1991 assessment data. Hence, there is risk that the current cost may be too low, suggesting the need for an updated utility assessment.

- <u>Shared Utility Costs</u>: Private utility relocation costs are assumed to be split 90/10 (project/private). The fact that the utility company bears any cost reduces the incentive perform the relocations promptly, increasing the likelihood the project may bear 100% of the relocation cost in order to maintain schedule.

<u>Stations</u>

- Station Platform Length: The current platform is designed to accommodate three-car consists. Honolulu may wish to consider station platforms long enough to accommodate four-car consists, to ensure sufficient capacity to meet long-term passenger volumes.

- Park-and-Ride Not Well Defined: The Park-and-Ride/Transit Center locations are not well defined in the estimate, and hence represent a source of project cost risk. All that is provided are numbers of at-grade or garage parking spaces, or bus bays. The footprint and other attributes of these facilities need to be more clearly defined.

- Stacked Train Station: The stacked station design under consideration for one of the stations in Segment 5 needs to be further refined. Local engineering opinion is that this design may not be feasible and would be very costly to both design and construct.

Constructability

- Constructability Factor of 30% for Segment 5: The current cost estimate for Segment 5 (located in the central business district, CBD) contains a 30% factor to cover the cost of "productivity issues" associated with construction in a dense urban environment. The costs covered by this factor need to be better defined and identified (e.g., traffic protection, access for equipment and material, staging areas, etc.)

F. *Key Findings – Managed Lanes Cost Assessment*

In response to concerns regarding the estimation procedures for the Managed Lanes alternative (alternative 3) versus those used for the proposed Fixed Guideway investment (alternative 4), the project cost estimates for both of these alternatives were compared to identify any potential cases of analysis bias in favor of one modal alternative over the other. To complete this assessment, the following two comparison activities were completed:

1. Comparison of detailed unit cost assumptions; and,
2. Comparison of the cost build-up process for the Managed Lanes and Fixed Guideway alternatives.

Based on this analysis, it was determined that both the unit costs and the cost build-up process were exactly the same for both the Managed Lanes and Fixed Guideway alternatives. Moreover, Honolulu project staff verbally confirmed that the unit costs and process for building up the two alternatives were, in fact, exactly the same. Hence, no evidence was found indicating a bias in favor of one modal alternative over the other.

II. PROJECT DEFINITION AND DATA SOURCES

A. *Project Definition*

The analysis for this cost validation exercise is based on the "New Starts" project definition. The segments included in this current definition are highlighted below (Exhibit II-1) along with their relation to the definitions considered for both LPA selection and Environmental Impact Statement (EIS) analysis.

Exhibit II-1
Alternate High-Capacity Transit Corridor Project Definitions

Section	Alignments Being Considered	Alternatives	LPA	EIS	New Start Project
1. Kapolei to Ft Weaver Road	Kamokila Blvd / Farrington Hwy	Alt 1	yes	no	no
		Alt 2			
	Kapolei Pkwy / North-South Rd	Alt 3			
		Alt 4			
	Saratoga Ave / North-South Rd	Alt 5	yes	yes	partial
		Alt 6	alternate	alternate	alternate
	Geiger Rd / Ft Weaver Rd	Alt 7			
		Alt 8			
II. Ft Waever Rr to Aloha Stadium	Farrington Hwy / Kamehameha Hwy	Alt 1	yes	yes	yes
III. Aloha Stadium to Middle Street	Salt Lake Blvd	Alt 1			
		Alt 2	yes	yes	yes
	Mauka of the Airport Viaduct	Alt 3			
		Alt 4			
	Makai of the Airport Viaduct	Alt 5			
	Aolele Street	Alt 6	yes	yes	no
IV. Middle Street to Iwilei	North King Street	Alt 1			
		Alt 2			
	Dillingham Blvd	Alt 3	yes	yes	yes
V. Middle Street to Iwilei	Beretania St / South King Street	Alt 9			
		Alt 10			
	Hotel Street / Kawaiahaʻo St / Kapi'olani Blvd	Alt 1			
		Alt 2			
	King St Tunnel / Waimanu St / Kapi'olani Blvd	Alt 4			
		Alt 5			
	Nimitz Hwy / Queen St / Kapi'olani Blvd	Alt 5			
		Alt 6			
	Nimitz Hwy / Halekauwila St / Kapiʻolani Blvd	Alt 7			
		Alt 8	yes	yes	partial
	Waikīkī Branch	Alt 11	yes	yes	no

B. *Data Sources*

The cost validation analysis was developed using the following key information sources:

- Final Capital Costing Memorandum, Product 8.5 – Honolulu High-Capacity Transit Corridor, Alternative Analysis/Draft Environmental Impact Statement, dated October 23, 2006 (~630 pages, Parsons Brinkerhoff Quade and Douglas): This document provides detailed cost estimates – including unit costs and quantities – for each project alternative by alignment and segment.

- Project Definition Memo (4/17/2007; City and County of Honolulu): This memo was provided to BAH in response to questions regarding the definition and costs of each segment of the LPA/New Start Project.
- PowerPoint Presentation: Honolulu High-Capacity Transit Corridor Project, Overview of Project – May 2007
- Summary (Preliminary) Cost Comparison of Alternative Analysis ($2007)
- Final Alignment Plans and Profiles – October 2006
- Final Station Conceptual Plans – November 2006
- Draft Typical Structural Details – September 2006
- Draft Maintenance and Storage Facilities Layout and Location Plans – February 2007
- Cost Data Book, Pacific Division, Naval Facilities (NAVFAC) Engineering Command, Pearl Harbor, Hawaii, January 2002 – on CD;
- NAVFAC Construction Cost Index – Historical and Projected, January 2005 - on CD
- Tabulation of Bids for various Oahu highway construction projects (in hard copies), namely:
    - Kamehameha Highway – Halawa Stream Bridge (Inbound) Replacement, Bids Opened June 28, 2001; and
    - Interstate H-3, H-3 Finish (Unit VIII) and Interstate Route H-1 Seismic Retrofit, Austin-Bishop Separation and Waiau Interchange, Bids Opened November 26, 2003
- FTA's Light Rail Capital Cost Study Update (2003) and Heavy Rail Capital Cost Study Update (2004) reports and accompanying databases

In addition, data were obtained through on-site interviews and meetings conducted with the grantee and the grantee's consultant staff.

III. TOP-DOWN COST VALIDATION

A. *Process*

For the top-down cost validation, the cost estimates for the High-Capacity Transit Corridor – including the total project costs and the costs for each SCC cost category and related elements – were compared and contrasted with their *expected* cost based on the historical cost experience of U.S. light and heavy rail projects completed within the past two decades. The cost data for this analysis were obtained from databases developed by FTA for the Light Rail Capital Cost Study Update (2003) and Heavy Rail Capital Cost Study Update (2004).

In addition to documenting the as-built costs and project characteristics of close to fifty U.S. light and heavy rail investments (recoded using codes largely the same as the current SCC codes)[1], these databases include "tools" designed to contrast the cost estimates of a specific project (e.g., the Honolulu High-Capacity Transit Corridor Project) with historical cost experience as represented by the projects recorded in the database. Specifically, these tools are designed to identify where the cost estimates for a project under analysis differ materially from the historical projects recorded in the database. Follow-up analyses (both in and outside the model) where then applied to determine the reason for these cost differences and whether they are justified.

For this report, the total project cost estimate for each SCC cost category and for each major cost category element was compared to the total *expected* cost for that category/element based on the as-built cost experience of those projects in the cost database. Subsequent analysis then focused on those items where the project cost estimate and the expected cost (based on historical experience) differed materially. To the extent possible, the project team then sought to determine the reasons for any significant such cost differences. It is important to note that a material difference is not an indication that these cost estimates are problematic, only that the project cost estimate differs from past experience as represented by the projects recorded in the FTA database. In most cases, these cost differences typically reflect the specific design needs of the project under analysis.

[1] Note: FTA's Light and Heavy Rail Capital Cost Databases both use an asset classification scheme that pre-dates the current SCC codes (the SCC code structure was derived from the classification used by the LRT and HRT Capital Cost Databases). Hence, while many of the codes used by the LRT and HRT Capital Cost Databases are similar to those used by the SCC worksheets, they are not exactly the same. FTA is currently working to reformat costs from the LRT and HRT Capital Cost Databases into the current FTA SCC structure.

FTA's Light and Heavy Rail Capital Cost Databases – These databases document the as-built costs for 21 LRT and 30 HRT investments.

- Project costs and quantities are reported using a modified SCC structure, including eight cost categories with roughly five to ten cost elements per category.
- Records document the cost, quantity, and purchase date / mid-point of construction for each cost element.
- All costs are adjusted to a common basis (e.g., national, $2007) to account for cost escalation and differences in regional costs.
- Databases developed by FTA to:
  - Support PMO cost validation reviews; and,
  - Develop quick estimates of project costs for projects in the conceptual stage

B. *Analysis Calibration for Honolulu Analysis*

To facilitate cost validation analysis of the Honolulu High-Capacity Transit Corridor Project, the cost data were modified/utilized as follows:

- Common Cost Basis ($2007): All database costs were adjusted to a common, "$2007, Honolulu" dollars, using RS Means Construction indices for both:
  - Cost escalation (for inflation), and,
  - Regional cost adjustment (from original project city to Honolulu).

- Average Historic Unit Costs: The unit costs obtained from the FTA databases for this cost validation (e.g., cost per vehicle or cost per foot of track) represent the *average* historical project cost for each SCC cost category and cost category element across some or all projects in the database:
  - Where possible, these average costs were calculated using only those projects recorded in the FTA database that have characteristics comparable to the Honolulu High-Capacity Transit Corridor Project (e.g., preference was given to historical projects in areas with similar right-of-way environments and higher proportions of elevated alignment); and,
  - Separate average unit costs were calculated for light and heavy rail (i.e., these costs were not combined to calculate an "average" light / heavy rail cost)

- Project Costs Primarily Compared Against Historic Light Rail Costs: As noted above, the current Honolulu cost estimates were developed assuming LRT as the project technology. For this reason, this analysis used historical light rail costs for the top-down cost validation. One key exception to this rule was where historic light and heavy rail costs were combined as the basis of comparison for the elevated structure. This choice was justified on the grounds that the design characteristics for the aerial structure currently envisioned for Honolulu is larger then typical for light rail (with large structures, several major freeway flyovers and some construction in a dense urban core).

- Cost Comparison Based on Total Item Cost, Not Unit Cost: The final cost comparison for each SCC cost category and category element is based on differences in the *expected* cost for that category/element (i.e., average database unit cost times project quantity) versus the *project* cost estimate for that category/element (i.e., project unit cost times project quantity)

- Comparison Uses Fully Allocated Contingencies: The Honolulu project costs used for this top-down validation exercise include fully allocated contingencies (providing a better 'apples-to-apples' comparison with the as-built costs in the database).

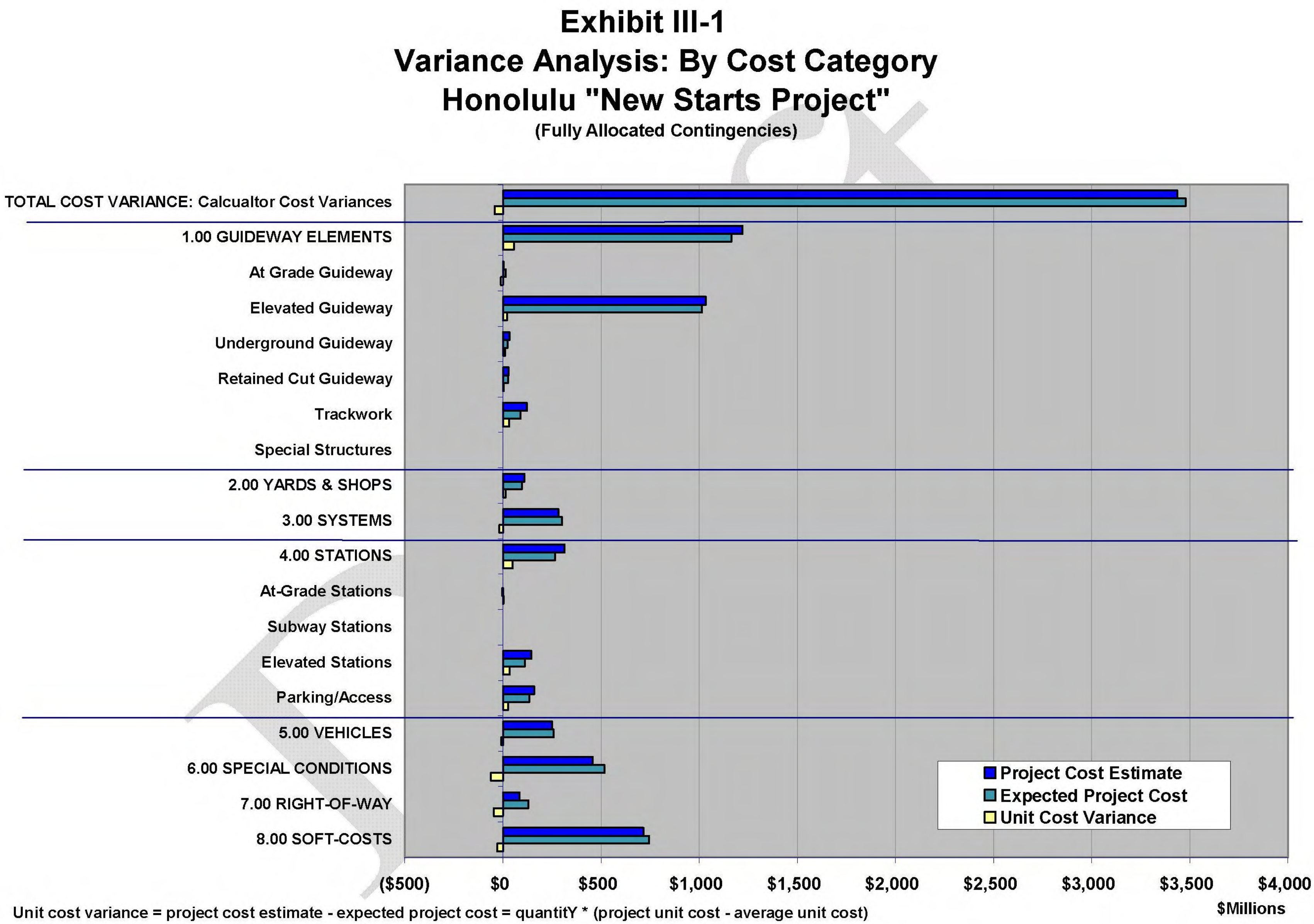
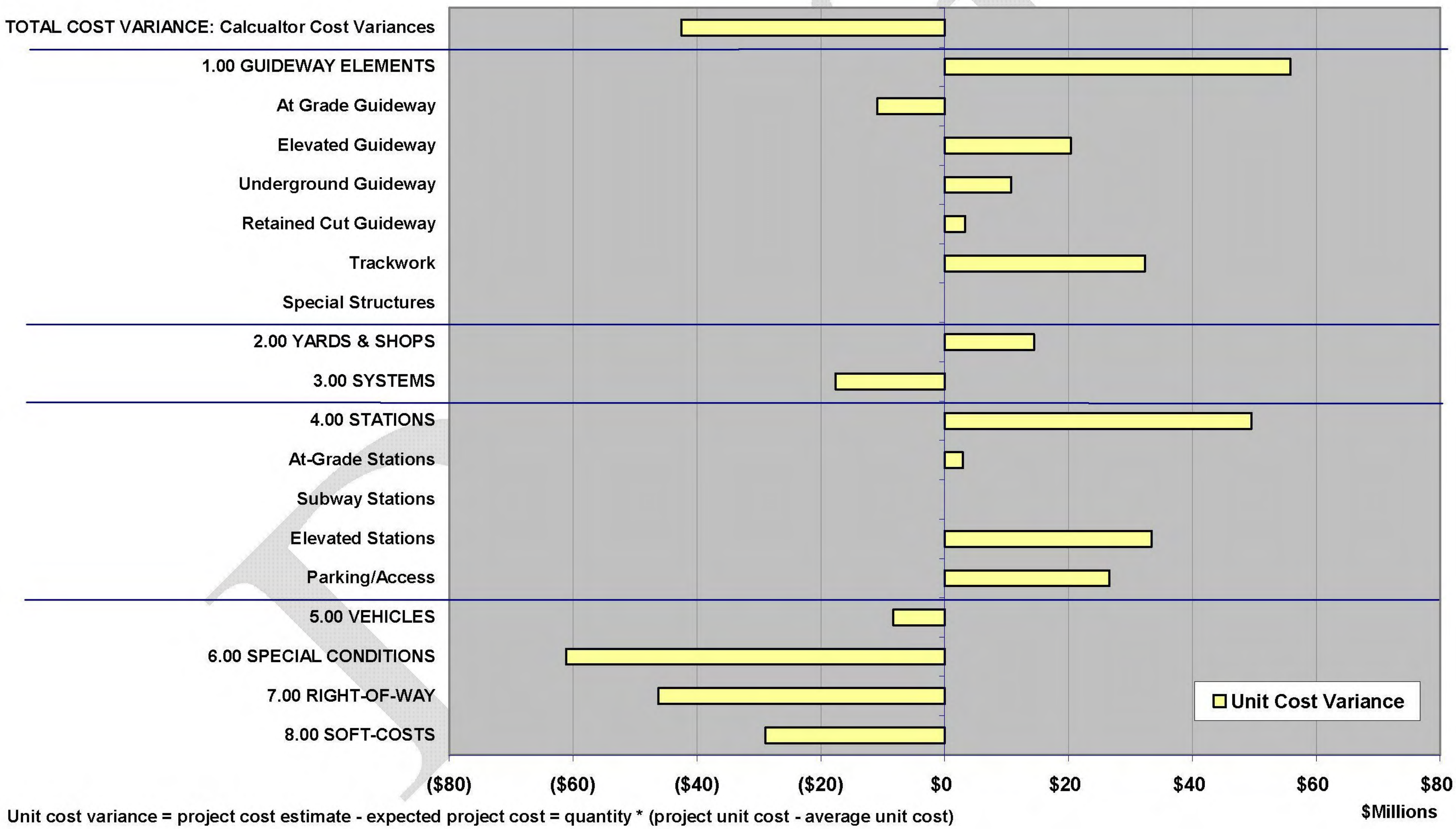


Exhibit III-1
Variance Analysis: By Cost Category
Honolulu "New Starts Project"
(Fully Allocated Contingencies)
TOTAL COST VARIANCE: Calcualtor Cost Variances
1.00 GUIDEWAY ELEMENTS
At Grade Guideway
Elevated Guideway
Underground Guideway
Retained Cut Guideway
Trackwork
Special Structures
2.00 YARDS & SHOPS
3.00 SYSTEMS
4.00 STATIONS
At-Grade Stations
Subway Stations
Elevated Stations
Parking/Access
5.00 VEHICLES
6.00 SPECIAL CONDITIONS
7.00 RIGHT-OF-WAY
8.00 SOFT-COSTS
Project Cost Estimate
Expected Project Cost
Unit Cost Variance
($500)
$0
$500
$1,000
$1,500
$2,000
$2,500
$3,000
$3,500
$4,000
$Millions
Unit cost variance = project cost estimate - expected project cost = quantitY * (project unit cost - average unit cost)

Exhibit III-2
Variance Analysis: By Cost Category
Honolulu "New Starts Project"
(Fully Allocated Contingencies)



Unit cost variance = project cost estimate - expected project cost = quantity * (project unit cost - average unit cost)

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C. *Analysis Results*

The results of the top-down cost validation analysis are presented graphically in Exhibits III-1 and III-2 (above) and as a table in Exhibit III-3 (below). For the project as a whole, as well as for each cost category and several major category elements, Exhibit III-1 presents:

1. The actual project cost estimate for a given category or element;
2. The *expected* cost of that category or element based on the historic costs from the cost database (i.e., average historic unit cost * project unit quantity); and,
3. The difference or "unit cost variance" between these two values (i.e., project cost estimate minus the expected cost). Note that this is a "unit cost" variance as the *quantities* are the same for the project and expected cost estimates, however the unit costs (expected and project actual) are different.

In contrast, Exhibit III-2 presents only the cost variances, which helps focus attention on those cost categories with the greatest cost variances. Exhibit III-3 presents the cost values behind all of these results in tabular form. Following are analyses of the results presented in these exhibits, beginning with a discussion of the individual cost categories then followed by an assessment of the total project cost:

Exhibit III-3
Cost Variance Analysis by Cost Category

Cost Category	Project Cost Estimate	Expected Cost Based on Prior Cost Experience	Difference	Percent Difference
1.00 Guideway Elements	$1,220.5	$1,164.7	$55.8	4.8%
2.00 Yards & Shops	$110.2	$95.8	$14.4	15.1%
3.00 Systems	$283.2	$300.9	($17.6)	-5.9%
4.00 Stations	$314.5	$264.9	$49.5	15.8%
5.00 Vehicles	$250.0	$258.4	($8.3)	-3.2%
Total: Categories 1.00 To 5.00	$2,178.5	$2,084.7	$93.8	4.5%
6.00 Special Conditions	$457.3	$518.5	($61.2)	-11.8%
7.00 Right-Of-Way	$84.4	$130.6	($46.3)	-35.4%
8.00 Soft-Costs	$715.7	$750.6	($34.9)	-4.6%
Total: Categories 6.00 To 8.00	$1,257.4	$1,393.8	($136.3)	-9.8%
Total Cost Variance:	**$3,435.9**	**$3,478.5**	**($42.5)**	**-1.2%**

<u>Total Project Cost:</u> The top-down analysis suggests that the current project cost estimate for the New Starts definition of the High-Capacity Transit Corridor is roughly $42 million, or roughly 1.2%, lower than the project's expected cost based on the sample of projects recorded in FTA's Capital Cost Databases. As discussed further below, the negative cost variances for special conditions (including utility relocations, roadway changes, demolitions and environmental mitigation), right-of-way acquisition, and soft-costs are the prime drivers of the slightly less than expected project cost (based on prior cost experience). In contrast, the current project cost estimates exceed the database predicted values for guideway elements (track and structure), yards & shops, and stations.

Given the current level of project definition (pre-PE), an overall project cost variance on the order of $42 million (or 1.2%) is very small and much less than the unallocated project cost variance of roughly $200 million[2]. Note, however, that the small project cost variance is also the product of several offsetting errors (i.e., the cost estimates for some cost categories are lower than expected while others are higher). When the analysis is limited to "hard asset" costs alone, including track and structures, facilities, systems, stations, and vehicles (i.e., including the first five asset categories but omitting special conditions, ROW acquisition and soft-costs), project cost estimates are found to marginally exceed the database predicted costs by roughly $95 million (or roughly 4.5%), again quite reasonable for a pre-PE project. In contrast, the combined project cost estimates for special conditions, ROW, and soft-costs were found to be roughly $135 million, or 10%, lower than expected based on prior project experience as represented in the FTA database. This level of variation suggests that those last three categories may benefit from further investigation of the build-up for their costs, analysis which is provided in the risk analysis section below.

It is helpful here to further emphasize the distinction between the first five categories presented in Exhibits III-1 through III-3 (i.e., guideway elements, yards & shops, systems, stations, and vehicles) and the last three (special conditions, ROW, and soft-costs). The first five categories consist, primarily of the purchase or construction of "hard" assets, many of which have relatively standardized costs (e.g., trackwork and vehicles). Where the costs of elements in these five categories are not standardized (e.g., stations, facilities), the costs for these categories are still relatively predictable given some understanding of the design specifications of each element (e.g., stations are elevated with no enclosures or passenger amenities, etc.). In contrast, the costs for the last three cost categories – in particular special conditions and right-of-way acquisition – tend to vary significantly between projects. This due to the very unique nature of utility relocation needs, alignment location relative to existing real estate development, environmental mitigation requirements, etc. within each investment corridor. In short, these costs tend to be highly sensitive to alignment location, utility location, the level of development in the corridor, and other factors.

Therefore, the fact that special conditions, ROW, and soft-costs account for much of the negative cost variation in Exhibits III-1 through III-3 (i.e., between the project cost estimates and the historical database values) is not unusual, but still grounds for further investigation. As discussed further below (under project risk), follow-on analysis has identified additional reasons for suspecting that the cost estimates for these cost categories may be underestimated and the Honolulu High-Capacity Transit Corridor Project team may want to revisit these cost estimates (in particular those for special conditions and right-of-way acquisition) as they move towards PE.

<u>1.0 Guideway Elements:</u> Guideway elements include the cost of track and the base on which that track resides, including at-grade, aerial, subway and retained cut and retained fill guideway. On the whole, the estimated project cost for guideway elements of $1.2 billion was

[2] Note all allocated contingencies have been included in this cost validation analysis whereas the $206 million in unallocated contingencies or "project reserves" have not been included, and hence do represent an additional "buffer" to address unexpected cost increases.

found to be only $55 million (less than 5%) higher than expected based on prior cost experience. Given the current level of project definition (pre-PE), this level of cost variation is not material (i.e., the cost estimates for guideway elements are reasonable based on prior cost experience).

It is important to reiterate here that the project cost estimates for elevated structure were compared to a mix of historic light and heavy rail projects costs (as opposed to light rail alone). This is because the proposed Honolulu structures are larger than typical for light rail (higher, with some high freeway flyovers and some elevated alignment in the dense CBD). Comparison to historic LRT elevated structure costs alone erroneously suggests that the elevated costs are much higher than expected (which is not a valid comparison). Using both light and heavy rail historic costs provides a more meaningful basis of comparison. Given this assumption, the project cost of $1.01 billion for aerial guideway structure exceeds the expected cost as determined by the FTA database model by only $20 million, or 2%.

As to the other guideway elements components, the cost estimates for both underground guideway and retained guideway were higher than expected (by 31% and 11%, respectively) while the estimated cost for at-grade guideway was far lower than expected based on prior cost experience (by more than 200%). Note that each of these elements represents only a small share of the total project costs. Trackwork costs were roughly 25% higher than expected based on prior cost experience. Note, however, that the current cost databases – which segment track costs into ballasted, embedded and direct fixation – do not distinguish trackwork costs based on grade, and with 18 of 20 miles of alignment being aerial structure, it should be anticipated that track costs will be higher as compared to the primarily at-grade track install costs recorded for LRT projects in the FTA database.

<u>2.0 Yards & Shops:</u> As with most of the "hard" asset investments, the estimated cost for the facilities, yards and shops investments of $110 million is marginally higher than expected based on prior cost experience alone. Specifically, the project yards and facilities estimates exceed the database predictions by roughly $27 million, or 9.6%. Note that this higher-than-expected cost estimate represents a modest "over sizing" of the facility to support future build-out of the full project (i.e., including each of the LPA extensions). Hence, this higher-than-expected cost estimate is both reasonable and founded on a logical assumption.

<u>3.0 Systems:</u> The systems category includes all investments in train control, electrification / traction power, communications, fare collection, and elevators/escalators. Based on this analysis, the High-Capacity Transit Project cost estimate of $283 million is roughly $17 million, or just under 6%, less as compared to that predicted by the FTA database. Based on the FTA database model, most of this negative cost variance originates with elevators and escalators, which were found to be less expensive than was documented for prior projects (accounting for the number of elevators/escalators used in the project plans). It should be noted here that the number of elevators and escalators assumed for the current stations (i.e., two elevators and four escalators at each of the 17 elevated stations, remains a preliminary stations design assumption that may be subject to change).

4.0 Stations: The project cost estimates assume two at-grade stations, seventeen elevated stations, and park-and-ride facilities, with a total of 4,500 surface spaces and 1,600 spaces in parking structures. For this top-down analysis, the project's station cost estimate of $314.5 million for stations was found to be roughly $49.5 million, or over 18%, higher than was estimated using the FTA database tool. This result was not unexpected. When considered apart from other station costs, the project cost estimate for aerial stations is $111.7 million, which is $33.4 million, or about 23%, higher than that predicted by the FTA database model. The current design for these stations calls for a fairly simple, open station design featuring canopies, proof-of-payment fare systems, and elevators, and hence are comparable to most existing, aerial light rail transit stations. However, as compared to the other aerial light rail stations documented in the FTA database, the Honolulu project stations are supported on higher and substantially heavier aerial structure, and subsequently are more expensive. Taking this key difference into account, these higher station costs appear reasonable.

In contrast, the cost estimate of $6.1 million for the two at-grade stations is lower than the $9.1 million expected cost based on recent cost database experience for similar LRT projects. The cost of station access (including bus, pedestrian and auto access and auto parking) of $160.4 million is roughly $25 million, or 16%, higher than expected based on prior cost experience. The current project descriptions and conceptual plans do not provide sufficient material to further assess the reasonability of either of these two cost elements (i.e., at-grade stations, station access including park-n-ride facilities).

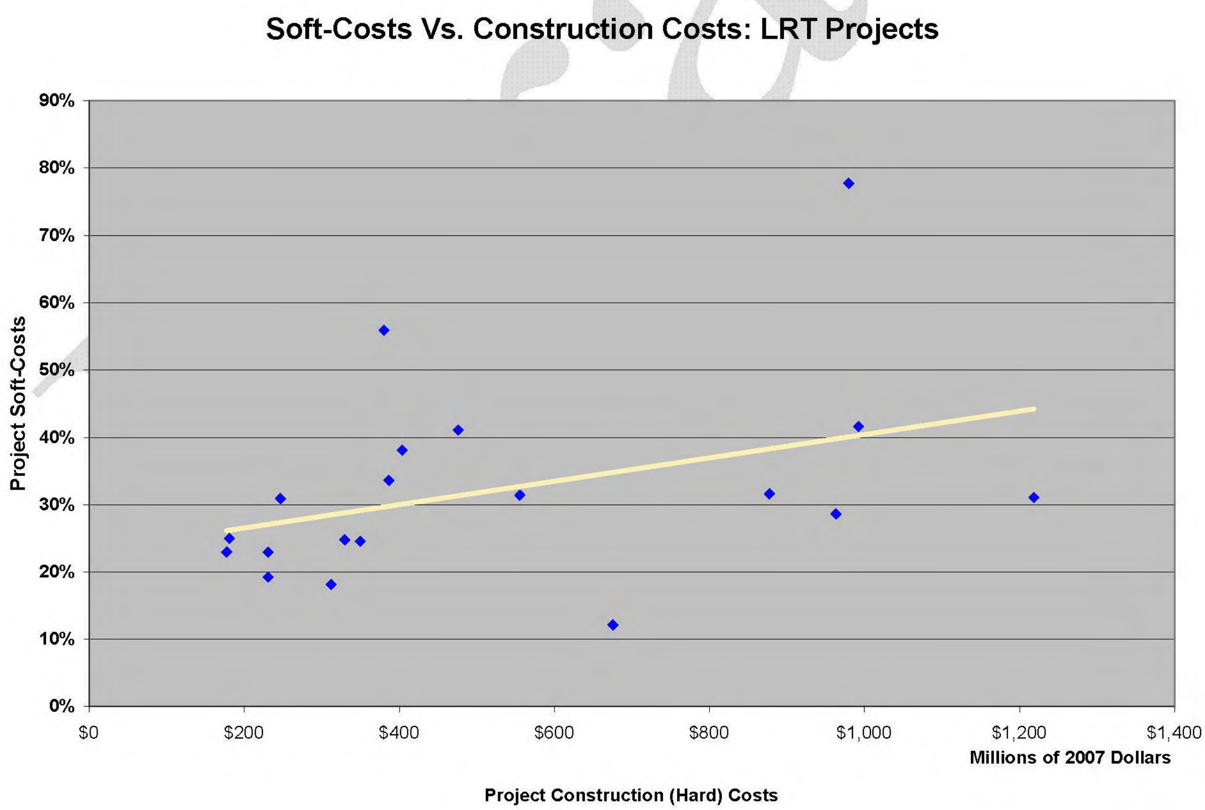
5.0 Vehicles: The current project cost estimates call for the purchase of 66 light rail vehicles. The project vehicle cost estimates of $250 million differed from the database estimates by only $8 million dollars or just over 3%. Hence, these vehicle cost estimates are considered reasonable.

6.0 Special Conditions: The project cost estimates for special conditions (including utility relocation, demolitions, roadway changes, environmental mitigation and landscaping) of $457 million were found to be roughly $60 million, or close to 12%, lower than expected based on the sample of projects in the FTA database. As discussed earlier, it should be expected that there will be more variation in the estimates for this cost category versus that for the prior five categories due to the fact that all investment corridors have quite unique special conditions investment needs (e.g., utility relocation needs are fairly sensitive to alignment location). That said, the risk analysis below does identify some further concerns with the current cost estimates for special conditions. Note that many of the assumptions used in developing these cost estimates were based on analyses completed in 1991.

7.0 Right-of-Way: The project cost estimates of $84.4 million for right-of-way (including ROW acquisition and business/residence relocation/compensation costs) were found to be roughly $46 million, or 35%, lower than expected based on the sample of historic LRT projects in the FTA cost database. In percentage terms, this was the largest cost variance across all eight cost categories recognized by the FTA cost databases. A key source of this significant negative cost variation is associated with relocation and compensation costs for businesses and residences negatively impacted by the alignment. Here, the project cost estimates only provide about $1.7 million in relocation costs while the database cost model predicts needs closer to $20 million. As with special conditions, all ROW costs, including relocation costs, are highly variable between projects based on the unique characteristics of each corridor. With that caveat in mind, Honolulu may still wish to revisit these cost estimates as much of the data used in their development rely upon analysis completed in 1991.

8.0 Soft-Costs: Project soft-costs include the cost of PE, final design, construction management, project management and oversight, finance charges, and training, testing and start-up. The project cost estimates of $715.7 million for soft-costs were found to be close to $30 million, or roughly 4%, lower than expected based on the sample of projects in the FTA cost database. Project staff justified this lower cost on the basis that projects whose costs are dominated by high expense items such as long aerial or subway alignment investments tend to have lower soft-cost expenditures (when expressed as a percent of hard costs). However, if anything, the relationship between soft costs and other project costs is a positive one based on analysis of the rail projects documented in the FTA Light and Heavy Capital Cost databases. In other words, not only do *total* soft-costs increase as project construction costs increase, but soft costs also account for an increasing (not decreasing) share of total project costs as project construction costs increase. This relationship is presented below in Exhibit III-4.

Exhibit III-4



Finally, Exhibit III-5 below compares assumed soft-costs as a percent of hard costs for the Honolulu project versus the average for light rail projects represented in FTA's Light Rail Capital

Cost Database. While there is a fair level of variation between categories (with the Honolulu project sometimes exceeding the historical light rail average), overall the Honolulu project has lower provision for soft-costs as compared to the historical light rail average.

Exhibit III-5
Soft-Costs As a Percent of Hard Costs – Light Rail Projects

Soft Cost	Light Rail Average	Honolulu Project	Difference
PE, Survey, Testing, Investigation, and Inspection	1.5%	3.5%	2.0%
Final Design	11.0%	4.5%	-6.5%
Project Management for Design and Construction	7.6%	5.5%	-2.1%
Construction Administration & Management	9.4%	10.0%	0.6%
Insurance-Professional Liability	1.5%	1.5%	0.0%
Legal, Permits, Review Fees by other agencies, cities, etc.	2.2%	1.5%	-0.7%
Agency: Force Account Work	1.1%	3.5%	2.4%
Total	**34.3%**	**30.0%**	**-4.3%**

D. *Finance Charges*

The current project cost estimates (including those presented in the SCC format) do not include any provision for Finance Charges. However, it is clearly the case that the project will be funded using the local dedicated sales tax newly approved for that purpose. The tax was initiated in 2007, sunsets in 2022, and only provides sufficient capacity to fund the 20-mile New Starts project definition (the project definition reviewed in the report). Hence, the current tax measure is not sufficient to fund the full-build out of the system without either an increase in the tax rate and/or some future extension beyond 2022. Regardless, the current project cost estimates do not include the cost of Finance Charges.

E. *Contingency and Cost Escalation Factors*

In addition to comparisons to expected project costs based on past U.S. rail transit investments, the cost validation analysis reviewed both the contingency and cost escalation factors used by the project.

> <u>Contingencies:</u> The contingencies assumed for development of the cost estimates for the New Starts fixed guideway investment are presented below in Exhibit III-6. Overall, these percentage contingency amounts are both reasonable and appropriate for a project coming out of the AA process and approaching PE.
>
> It is important to reiterate here that the cost comparison between the current project estimates for the Honolulu High-Capacity Transit Corridor Project with the experience of recent U.S. rail transit projects included the project's estimates for allocated contingencies. The analysis did not include the additional 6% unallocated contingency or project reserve amount.

Exhibit III-6
Contingency Assumptions – Honolulu "New Starts" Fixed Guideway Project

Standard Cost Category	Contingency
10.0: Guideway & Track Elements	25%
20.0: Stations, Stops, Terminals	25%
30.0: Yards, Shops, Admin/Support Facilities	25%
40.0: Sitework and Special Conditions	30%
50.0: Systems	25%
60.0: ROW, Land, Existing Improvements (contingency and engineering)	50%
70.0: Vehicles (contingency and engineering)	24%
80.0: Soft Costs	0%
Contingency/Project Reserve (10 thru 80)	6%

Cost Escalation Factors: The inflation rates currently used to convert the project's cost estimates from $2007 to $YOE are presented below in Exhibit III-7, along with two historical cost indices for reference. Based on comparisons with the recent historical inflation rates for construction costs (nationally) and consumer prices for Honolulu residents, the assumed inflation rates appear reasonable but are not conservative (especially in the later years of construction). Note that this analysis assumes construction will begin in 2007 and conclude in 2018.

Exhibit III-7
Cost Escalation Factors – Honolulu "New Starts" Fixed Guideway Project

Year	Assumed Rate for YOE$ Calculation	Historical Construction Costs (Means)	Historical CPI (Honolulu)
2000		2.8%	1.7%
2001		3.5%	1.2%
2002		2.9%	1.1%
2003		2.6%	2.3%
2004		8.9%	3.3%
2005		5.5%	3.8%
2006			5.9%
2007			
2008	5.0%		
2009	4.3%		
2010	3.5%		
2011	3.3%		
2012	3.0%		
2013	3.0%		
2014	3.0%		
2015	3.0%		
2016	3.0%		
2017	3.0%		
2018	3.0%		
2019	3.0%		
Average	3.3%	4.3%	2.8%

F. *Summary*

In summary, the cost validation analysis has determined that the total project cost estimates are reasonable, falling marginally below (roughly $42 million or less than 2%) the expected cost estimated using FTA's cost database model. This amount is less then the $206 million included for unallocated contingencies or project reserves. However, this low overall project cost variance is also the product of offsetting positive and negative cost variances across the eight cost categories recognized by the database cost model. Specifically, when the variance analysis is limited to "hard asset" costs alone, including track and structures, facilities, systems, stations, and vehicles, project cost estimates are found to marginally exceed the database predicted costs by roughly $95 million (or roughly 4.5%), again quite reasonable for a pre-PE project. Moreover, much of this positive cost variance for these "hard" cost elements were determined to be reasonable based on the proposed design characteristics of the Honolulu project (e.g., higher aerial structures as compared to those found for LRT projects documented in the FTA cost database). In contrast, the combined project cost estimates for special conditions, ROW, and soft-costs were found to be roughly $135 million, or 10%, lower than expected based on prior project experience as represented in the FTA database. This level of variation suggests that those last three categories may benefit from further consideration by Honolulu project staff.

Finally, the provisions for contingencies were found to be adequate and appropriate for a project in the pre-PE phase. Also, the assumed inflation rates used to adjust project costs from $2007 to $YOE were found to be reasonable but not conservative, based on recent cost inflation for construction projects nationally and local Honolulu consumer cost inflation.

IV. <u>UNIT COST VALIDATION</u>

The cost validation effort also reviewed a sample set of Parsons Brinckerhoff Quade & Douglas, Inc.'s (PBQD) unit costs that were used in the Alternative 4 - Fixed Guideway estimate for the Honolulu High-Capacity Transit Corridor Project. The selected unit costs and their associated back-up were compared with industry norms and historical data as part of the validation effort.

Specifically, Booz Allen assessed the reasonableness of PBQD's unit costs for site work (common and structural excavation), reinforcing steel, and concrete line items that were used in the Fixed Guideway estimate for this Honolulu project. These unit costs were derived from the Final Capital Costing Memorandum, Product 8.5 – Honolulu High-Capacity Transit Corridor, Alternative Analysis/Draft Environmental Impact Statement, dated October 23, 2006.[3] The objective of this evaluation was to determine if these unit costs were within acceptable ranges presented in various industry references and local historical data.

Booz Allen compared the selected PBQD's unit costs item with the following cost references and sources:

- RS Means 2006 Heavy Construction Cost Data;
- Cost Data Book, Pacific Division, Naval Facilities (NAVFAC) Engineering Command, Pearl Harbor, Hawai'i, January 2002; and,
- Tabulation of Bids for various O'ahu highway construction projects.

A. *PBQD's Unit Costs*

PBQD's unit costs in the Fixed Guideway estimate reflect 2006 dollars. Furthermore, PBQD's unit costs include the following costs:

- labor costs;
- equipment costs;
- material costs;
- general conditions costs[4]; and
- contractor profit[5].

PBQD's unit costs do not include contingency.

In addition, PBQD's unit cost for concrete assumes local production of the concrete materials (i.e., all concrete materials are available on the island of O'ahu, except for the reinforcing steel). Likewise, PBQD's unit pricing for structural steel/reinforcing steel assumes imported materials (i.e., all steel/rebar materials are <u>not</u> available on the island and must be transported to O'ahu).

[3] Prepared for the City and County of Honolulu by Parsons Brinckerhoff, Quade & Douglas, Inc.
[4] The percentage of general conditions applied to the direct costs (labor, equipment, and material) is pending confirmation from PBQD.
[5] The percentage of contractor profit applied is pending confirmation from PBQD.

B. *RS Means 2006 Heavy Construction Cost Data*

PBQD's unit costs were compared and contrasted against cost measures obtained from RS Means 2006 Heavy Construction Cost Data. The unit costs in this reference source were adjusted to reflect Honolulu pricing by using that city's cost index (or location factor). The index represents relative construction factors (or multipliers) for material and installation costs (labor and equipment), as well as the weighted average for total-in-place costs for each Construction Specification Institute, Inc. (CSI) Master Format division.

The RS Means Honolulu Cost Index for CSI Division 02 and 03 was used to adjust RS Means unit costs to reflect Honolulu pricing for the respective cost items (divisions). Specifically, for the applicable CSI Division, the RS Means 2006 Heavy Construction unit costs are multiplied by the applicable Honolulu Area Cost Factors as indicated:

- 02 - Site Construction 115.2%
- 03200 – Concrete Reinforcement 117.5%
- 03300 – Cast-in-Place Concrete 171.5%

Since both RS Means and PBQD's unit costs were given in 2006 dollars, no escalation was necessary.

Furthermore, since PBQD's unit costs included material, labor, equipment, and general conditions costs, as well as contractor profit, they were compared to RS Means "Total Cost including O&P" (overhead and profit). RS Means "Total Cost including O&P" is the sum of the bare material cost plus 10% for profit, the base labor cost plus total overhead and profit, and the bare equipment cost plus 10% for profit.

The table below (Exhibit IV-1) summarizes the comparison of PBQD and RS Means unit costs.

Exhibit IV-1
Comparison of PBQ&D Unit Costs with RS Means Unit Costs

Item Description	Unit of Measure	PBQ&D Alt. 4 - Fixed Guideway Unit Costs	RS Means - Heavy Construction Cost Data 2006		
Clearing & Grubbing, Light	sy	$ 0.72			$ 0.79
Clearing & Grubbing, Medium	sy	$ 1.05			$ 1.12
Clearing & Grubbing, Heavy	sy	$ 2.33			$ 2.64
Saw Cut Asphalt Pavement	lf	$ 3.53	$ 1.56	to	$ 3.10
Saw Cut Concrete Pavement	lf	$ 6.91	$ 2.71	to	$ 4.60
Asphaltic Pavement Removal	sy	$ 7.38	$ 4.73	to	$ 7.78
Concrete Pavement Removal	sy	$ 24.09	$ 12.79	to	$ 16.36
Concrete Sidewalk (4")	sf	$ 6.18	$ 4.12	to	$ 5.17
Concrete Curbs (4")	lf	$ 12.84			$ 9.50
Concrete Curbs and Gutter	lf	$ 25.05	$ 25.92	to	$ 28.22
Concrete Pavement	cy	$ 369.33	$ 185.52	to	$ 231.65
Steel Sheet Piling (Installed)	sf	$ 24.09	$ 21.54	to	$ 32.83
Reinforced Concrete Pipe - Class IV,18" dia. (In place)	lf	$ 46.64			$ 37.44
Reinforced Concrete Pipe - Class IV, 24" dia. (In place)	lf	$ 62.73			$ 50.11
Reinforced Concrete Pipe - Class IV, 30" dia. (In place)	lf	$ 118.22			$ 93.89
Reinforced Concrete Pipe - Class V, 15" dia. (In place)	lf	$ 47.04			$ 32.83
Reinforced Concrete Pipe - Class V, 18" dia. (In place)	lf	$ 54.43			$ 38.02
Reinforced Concrete Pipe - Class V, 21" dia. (In place)	lf	$ 64.57			$ 44.93
Reinforced Concrete Pipe - Class V, 24" dia. (In place)	lf	$ 72.88			$ 50.69
Trench Excavation	cy	$ 13.65	$ 2.47	to	$ 9.96
Structural Excavation	cy	$ 19.27	$ 10.43	to	$ 24.77
Finish Grading	sy	$ 0.97	$ 0.41	to	$ 0.96
Aggregate Base	cy	$ 30.91	$ 27.07	to	$ 48.38
Asphaltic Concrete Pavement (Large/Medium Qty.)	ton	$ 86.04	$ 63.36	to	$ 66.24
Reinforcing Steel (In place)	lbs	$ 1.09	$ 0.94	to	$ 1.10
Reinforcing Steel, Epoxy Coated (In place)	lbs	$ 1.29	$ 1.36	to	$ 1.60
CIP Concrete, Floor Slab / Slab on Grade	cy	$ 400.00	$ 282.65	to	$ 337.46
CIP Concrete Elevated Platform Slab	cy	$ 650.00	$ 890.76	to	$ 1,010.67
CIP Concrete Footings	cy	$ 297.07	$ 385.43	to	$ 599.55
CIP Concrete Walls	cy	$ 449.62	$ 501.91	to	$ 805.11

Notes:
All unit costs reflect 2006 costs.
All unit costs reflect Honolulu area pricing.
All unit costs are burdened costs.

As presented, the PBQD unit costs, except those associated with cast-in-place (CIP) concrete, were typically greater than their RS Means counterparts, but within an acceptable range of +30%. However, the PBQD CIP concrete unit costs showed a greater variation when compared to the RS Means line items. A possible explanation for this can be attributed to the fact the concrete line items given in the RS Means Heavy Construction reference book are typically for vertical construction (building construction) and PBQD's CIP concrete unit costs were representative of transportation- and bridge-related construction. Furthermore, various CIP concrete (e.g. 6-ft diameter concrete columns), precast concrete, and precast prestressed concrete elements used in PBQD's estimate had no similar matches in RS Means, and thus could not be compared.

C. *NAVFAC Cost Data Book*

The NAVFAC Cost Data Book, *Pacific Division, Pearl Harbor, January 2002*[6] is used by NAVFAC's Pacific Division Specifications and Cost Engineer Branch to develop of cost estimates for new construction, repair work, and maintenance work to be accomplished in the Pearl Harbor/Honolulu area. The cost data were obtained from a number of sources, including quotations from local vendors and suppliers, contractors, U.S. Department of Labor prevailing wage rates, detailed estimates prepared by the Specification and Cost Engineering Branch, and other records on file with Pacific Division, Naval Facilities (NAVFAC) Engineering Command.

All costs derived from this NAVFAC Cost Data Book are in-place costs unless otherwise noted. In-place costs include direct prices of materials, labor, equipment, and thirty-five percent mark-up on direct material, labor and equipment. Labor includes fringe benefits, social security, unemployment liability and compensation insurance. The 35% mark-up includes contractor's profit, overhead, taxes, and other contractual costs.

Since PBQD's unit costs were given in 2006 dollars[7] and the NAVFAC Cost Data Book had a publication date of January 2002, an escalation factor of 18.93% was used to inflate the 2002 costs to 2006 dollars[8]. This escalation factor (18.93%) was calculated using the "NAVFAC Construction Cost Index – Historical and Projected, January 2005"[9].

Since both NAVFAC and PBQD's unit costs represented Honolulu area pricing, no area or location factor was applied.

The following table (Exhibit IV-2) compares the PBQD and NAVFAC unit costs.

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[6] Provided to Booz Allen by PBQD on May 9, 2007.
[7] PBQD's unit costs were derived from the Final Capital Costing Memorandum, Product 8.5 – Honolulu High-Capacity Transit Corridor, Alternative Analysis/Draft Environmental Impact Statement, dated October 23, 2006.
[8] January 2002 index = 3581; October 2006 index= 4259; Escalation Factor = (4259 – 3581) / 3581 x 100% = 18.93%; from "NAVFAC Construction Cost Index – Historical and Projected", January 2005.
[9] Provided to Booz Allen by PBQD on May 9, 2007.

Exhibit IV-2
Comparison of PBQ&D Unit Costs with NAVFAC Unit Costs

Item Description	Unit of Measure	PBQ&D Alt. 4 - Fixed Guideway Unit Costs	NAVFAC Cost Data Book Unit Costs		
Clearing & Grubbing, Light	sy	$ 0.72	$ 0.14	to	$ 0.27
Clearing & Grubbing, Medium	sy	$ 1.05	$ 0.68	to	$ 0.81
Clearing & Grubbing, Heavy	sy	$ 2.33	$ 1.35	to	$ 2.03
Saw Cut Asphalt Pavement	lf	$ 3.53			$ 2.79
Saw Cut Concrete Pavement	lf	$ 6.91			$ 4.35
Asphaltic Pavement Removal	sy	$ 7.38	$ 5.47	to	$ 9.05
Concrete Pavement Removal	sy	$ 24.09	$ 12.63	to	$ 24.08
Concrete Sidewalk (4")	sf	$ 6.18			$ 8.27
Concrete Curbs (4")	lf	$ 12.84			$ 34.17
Concrete Curbs and Gutter	lf	$ 25.05			$ 36.25
Furnish Concrete Piling	lf	$ 32.12	$ 25.17	to	$ 67.08
Steel Sheet Piling (Installed)	sf	$ 24.09	$ 30.99	to	$ 46.18
Reinforced Concrete Pipe - Class IV,18" dia. (In place)	lf	$ 46.64			$ 73.27
Reinforced Concrete Pipe - Class IV, 24" dia. (In place)	lf	$ 62.73			$ 98.33
Reinforced Concrete Pipe - Class IV, 30" dia. (In place)	lf	$ 118.22			$ 141.47
Reinforced Concrete Pipe - Class IV, 48" dia. (In place)	lf	$ 254.91			$ 296.71
Structural Excavation	cy	$ 19.27	$ 22.00	to	$ 46.01
Finish Grading	sy	$ 0.97	$ 2.08	to	$ 3.50
Aggregate Base	cy	$ 30.91	$ 29.08	to	$ 49.68
Asphaltic Concrete Pavement (Small Qty.)	ton	$ 172.07	$ 166.50	to	$ 202.18
Asphaltic Concrete Pavement (Large/Medium Qty.)	ton	$ 86.04	$ 71.36	to	$ 83.25
Reinforcing Steel (In place)	lbs	$ 1.09			$ 1.57
Reinforcing Steel, Epoxy Coated (In place)	lbs	$ 1.29			$ 5.23
Structural Steel (Elevator & Escalator)	lbs	$ 5.45	$ 3.62	to	$ 5.07
CIP Concrete, Floor Slab / Slab on Grade	cy	$ 400.00	$ 407.49	to	$ 831.36
CIP Concrete Footings	cy	$ 297.07	$ 760.13	to	$ 1,179.20
CIP Concrete Walls	cy	$ 449.62	$ 731.75	to	$ 1,085.36

Notes:
All unit costs reflect 2006 costs.
All unit costs reflect Honolulu area pricing.
All unit costs are burdened costs.

As shown, the PBQD unit costs were typically less than their NAVFAC counterparts, and were not bounded within a consistent percentage envelope. In other words, NAVFAC's unit costs showed a greater variation, and were generally greater by 20% to over 150% for some items, when compared to PBQD's unit costs. A possible explanation for this can be attributed to the manner in which the cost data was presented in the two distinct sources. PBQD's listing of unit costs typically gave very minimal sizing parameters, while the NAVFAC Cost Data Book had more specificity in terms of sizing, dimensions, and more discrete descriptions of the costs items (e.g., CIP concrete footings vs. sizes of continuous concrete footings and concrete spread footings).

D. *Tabulation of Bids*

Booz Allen also reviewed two sets of Tabulation of Bids - *O'ahu Highway Construction Projects*[10] to facilitate the comparison of PBQD's unit costs used in the Fixed Guideway estimate. These bid tabulations were for the following two O'ahu projects:

- Kamehameha Highway – Halawa Stream Bridge (Inbound) Replacement, Bids Opened June 28, 2001: Unit costs for the bid items for four construction companies and the State of Hawai'i DOT Highways Division were tabulated).
- Interstate H-3, H-3 Finish (Unit VIII) and Interstate Route H-1 Seismic Retrofit, Austin-Bishop Separation and Waiau Interchange, Bids Opened November 26, 2003: Unit costs for the bid items for four construction companies and the State of Hawai'i DOT Highways Division were depicted.

Since the bids and PBQD's unit costs represented Honolulu area pricing, no area or location factor had to be applied. However, since the costs for the bid items were prepared (or opened) in June 2001 and November 2003, the appropriate escalation factor was used to inflate the respective bid items to 2006 dollars.

These escalation factors were calculated using the "NAVFAC Construction Cost Index – Historical and Projected, January 2005"[11]. They are as follows:

- Escalation Factor from June 2001 to October 2006 = 19.23%[12]
- Escalation Factor from November 2003 to October 2006 = 13.12[13]

Furthermore, since the unit costs found in the Tabulation of Bids were contractor unit prices, it is assumed that each contractor's mark-ups, as well as labor, equipment and material costs, have been included in their unit prices.

The table below (Exhibit IV-3) summarizes the comparison of the PBQD and Bid Tabulation unit costs.

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[10] Provided to Booz Allen by PBQD on May 9, 2007.
[11] Provided to Booz Allen by PBQD on May 9, 2007.
[12] June 2001 index = 3572; October 2006 index= 4259; Escalation Factor = (4259 – 3572) / 3572 x 100% = 19.23%; from "NAVFAC Construction Cost Index – Historical and Projected", January 2005.
[13] November 2003 index = 3765; October 2006 index= 4259; Escalation Factor = (4259 – 3765) / 3765 x 100% = 13.12%; from "NAVFAC Construction Cost Index – Historical and Projected", January 2005.

Exhibit IV-3
Comparison of PBQ&D Unit Costs with Bid Tabulations of Oahu Highway Construction Unit Costs

Item Description	Unit of Measure	PBQ&D Alt. 4 - Fixed Guideway Unit Costs	Tabulation of Bids Oahu Highway Unit Costs		
Concrete Sidewalk (4")	sf	$ 6.18	$ 3.97	to	$ 15.24
Concrete Sidewalk (4")	sf	$ 6.18	$ 5.03	to	$ 10.06
Concrete Curbs (4")	lf	$ 12.84	$ 23.85	to	$ 47.69
Concrete Curbs and Gutter	lf	$ 25.05	$ 29.81	to	$ 71.54
Concrete Curbs and Gutter	lf	$ 25.05	$ 28.28	to	$ 56.56
Concrete Pavement	cy	$ 369.33	$ 282.80	to	$ 565.60
Structural Excavation (Retaining Wall)	cy	$ 40.15	$ 33.94	to	$ 226.24
Asphaltic Concrete Pavement (Large/Medium Qty.)	ton	$ 86.04	$ 71.54	to	$ 125.19
Asphaltic Concrete Pavement (Large/Medium Qty.)	ton	$ 86.04	$ 73.53	to	$ 124.43
Reinforcing Steel (In place)	lbs	$ 1.09	$ 0.88	to	$ 1.49
Structural Concrete, Bridge	cy	$ 512.56	$ 308.89	to	$ 1,192.30
Concrete for Bridge Approach Slabs	cy	$ 475.96	$ 447.11	to	$ 745.19

Notes:
All unit costs reflect 2006 costs.
All unit costs reflect Honolulu area pricing.
All unit costs are burdened costs.

As presented, the PBQD unit costs were generally within the low-high ranges established by the various bids. Furthermore, in one of the Tabulation of Bids, the cast-in-place concrete for structural items such as abutments, columns, footings, closure pours, retaining/barrier walls, etc., as well as reinforcing steel, were given as lump sum costs, which precluded the calculation and comparison of unit costs since no quantities (cubic yards or pounds/tons) were given for these elements.

E. *Findings and Conclusions*

Overall, PBDQ's unit cost estimates for the Honolulu High-Capacity Transit Corridor Project were generally found to be similar to or within acceptable ranges to those derived from other existing sources, and hence should be considered reasonable at this stage of the project. A key exception here is the cost of cast-in-place concrete (a key project input), where the project unit costs appear to be substantially lower than those found using either the RS Means or NAVFAC sources. It is possible that this finding may result from differences in the assumed CIP investment dimensions across these sources. Obtaining local and more recent concrete vendor quotes may help settle this issue."

Other key results included the following:

- Project unit costs, except those associated with cast-in-place (CIP) concrete, were typically greater than their RS Means counterparts, but within an acceptable range of +30%.

- NAVFAC's unit costs were generally greater by 20% to over 150% for some items, when compared to the similar project unit costs. PBQD's listing of unit costs provides only minimal sizing parameters, while the NAVFAC Cost Data Book provides more specificity in terms of sizing, dimensions, and more discrete descriptions of the costs items.

- PBQD's unit costs were generally within the low-high ranges established by recent bids for highway construction in Hawaii.

- Given the recent price volatility in construction materials, current Honolulu market pricing for steel, asphalt, and concrete elements should be obtained to confirm any variances with the respective unit costs used in the PBQD estimate. Sources of such data can include contractor quotations and more current Hawaii DOT bid tabulations.

- Costs for heavy electrical installation/heavy traction power items given in the PBQD estimate could not be compared since no similar items were found in the RS Means, NAVFAC, and Tabulation of Bids reference sources.

V. COST RISK REVIEW

The cost review identified cost elements that either may be missing from the current estimates or which may benefit from further refinement to reduce cost risk. In completing this analysis, it is understood that the current cost estimates are based on AA information, and therefore, are based on minimal engineering (which will be augmented in PE). However, by addressing these issues now, the Honolulu project team will be better prepared to address questions FTA will pose as part of the current risk assessment process.

Following are items that may pose real cost risks to the project, and hence, deserve further attention during PE. These risk items were grouped into the four main areas were the identified risks were most prevalent: utilities, stations, project constructability, and environmental remediation.

A. *Utility Relocation Costs*

Underground Utilities Not Fully Reviewed Since 1991: The last comprehensive utility assessment for buried utilities was performed in 1991. This assessment consisted largely of a review of utility maps obtained from the City of Honolulu, which PBQD project staff do not consider to be very accurate or reliable, and also data obtained from some of the utility companies. In addition, there is a high likelihood of fiber optic cables that were installed after 1991. The current PBQD estimate consists of updated relocation costs applied to the 1991 assessment data for these buried utilities. Hence, there is risk that the current cost may be too low, suggesting the need for an updated utility assessment.

Shared Utility Costs: Utility relocation costs for the public utilities are borne 100% by the project, however relocation costs for private utilities are split between the project and the utility company. The project/private split is assumed to be 90/10, and the fact that the utility company needs to bear any of the cost reduces the incentive for the utility to perform the relocations promptly and increases the likelihood that the project may bear 100% of the relocation cost in order to maintain schedule. This total cost impact could be material.

B. *Stations*

Station Platform Length: The current platform length of 270 ft is designed to accommodate three car consists. Honolulu may wish to consider station platforms long enough to accommodate four car consists, to ensure sufficient capacity to meet long-term passenger volumes.

Consider Center Platforms: To eliminate the need for additional station infrastructure (e.g., elevators, escalators, fare collection devices, etc), Honolulu may wish to consider constructing the stations with center island platforms vs. the present design featuring side platforms. Center platforms may also help avoid the need to reposition riders between platforms in the event of a vehicle breakdown.

Universal Crossovers: Universal (double) crossovers may need to be located at both ends of every station in order to maintain operating headways in the event of a track outage. The present design has only one universal crossover per station. Additional crossovers would, of course, result in additional cost.

Park-and-Ride Not Well Defined: The Park-and-Ride and Transit Center locations are not defined clearly in the estimate. All that is provided are numbers of at-grade or garage parking spaces, or bus bays. The footprint of each Park-and-Ride location and Transit Center location should be more clearly defined as should the attributes of these facilities (e.g., number and length of canopies, other passenger amenities, parking fee collection equipment, etc.).

Station Intelligent Transportation Systems (ITS) Investments: The current station plans do not appear to include any provision for ITS components such as real-time passenger information (e.g., next- train arrival time). The Honolulu team may wish to determine whether such investments will be included.

Stacked Train Station: The stacked station design that will be used for one of the stations in Segment 5 needs to be further refined. Local engineering opinion is that this design cannot be accomplished. PBQD staff were asked to furnish an example of this type of design that is performing as intended in the transit world today. This station will be very costly to both design and construct, with many uncertainties to address.

C. *Constructability*

Constructability Factor of 30% for Segment 5: The current cost estimate contains a 30% productivity factor added to the total cost of Segment 5 (located in the CBD) to address "productivity issues" associated with construction in a dense urban environment. As the project moves into PE, the 30% factor needs to be refined and defined in more granular terms to include more specific costs for traffic protection, lack of productivity due to working in a dense urban area, access for equipment and material, staging areas, and other items covered under general conditions but exacerbated by the densely urban area.

D. *Environmental Remediation*

Contaminated Sites: PBQD has assumed that there may be fuel/oil contamination of soil surrounding known pipelines that cross the proposed alignment. They have identified specific quantities for both groundwater remediation and the removal of contaminated soil, and applied unit costs. They are unaware of the existence of any site exploration data from the 1991 estimate. As they have no direct knowledge of the type, limits, or extent of any contamination of either soil or groundwater, this number has been provided as a placeholder. The risk here is that the actual costs could easily exceed the estimate in all segments. A detailed site assessment should be performed very early in the PE process.

VI. MANAGED LANES COST ASSESSMENT

In response to concerns regarding the estimation procedures for the Managed Lanes alternative (Alternative 3) versus those used for the proposed Fixed Guideway investment (Alternative 4), the project cost estimates for both of these alternatives were compared to identify any potential cases of analysis bias in favor of one modal alternative over the other. To complete this assessment, the following two comparison activities were completed:

1. Comparison of detailed unit cost assumptions
2. Comparison of the cost build-up process for the Managed Lanes and Fixed Guideway alternatives

Finally, before discussing the results of these analyses, it should be noted that Honolulu project staff verbally confirmed that the unit costs and process for building up the Managed Lanes and Fixed Guideway alternatives were, in fact, exactly the same.

Unit Cost Comparison: This comparison reviewed the detailed unit cost assumptions for both the Managed Lanes and Fixed Guideway alternatives. Specifically, this process had the objective of identifying and comparing the costs of common construction inputs for both investment alternatives, including elements such as concrete components, steel rebar, excavation, etc. With minimal investigation, it was easily determined that the unit costs for these two alternatives were exactly the same and drawn from the same database. All of these unit cost assumptions are presented in Appendix C of the Final Capital Costing Memorandum. Hence, whatever the quality of the unit costs themselves (see the section on Unit Cost Validation for more on this), the unit costs applied to each alternative was exactly the same.

Cost Build-Up Comparison: This second analysis compared and contrasted the methods and assumptions used to build-up the cost estimates for both the Managed Lanes and Fixed Guideway alternatives. Here again, minimal review revealed that exactly the same cost build-up processes was applied for both alternatives. This was determined by reviewing the cost build-up presented in Appendix A (for the Managed Lanes alternative) with that in Appendix B (Fixed Guideway alternative) of the Final Capital Costing Memorandum. Specifically, these appendices present the project cost build-up from on the major subcomponent level up to the SCC cost category level.

As evidence that these cost build-up process are the same and yield similar results, refer to Exhibits VI-1 and VI-2 below. These present the cost per foot of guideway for sample project cost elements as well as the contingency factors applied to both alternatives. These exhibits demonstrate that the project costs (both for individual cost categories and in total), when expressed on a per foot of guideway basis, are quite similar for both alternatives and, if anything, appear to favor the Managed Lanes alternative. Similarly, the contingency percentages and soft-cost percentages used for the Managed Lanes and Fixed Guideway alternatives were also exactly the same.

Exhibit VI-1

Sample Project Costs per Foot of Guideway

Sample Per Foot Costs	Managed Lanes	Fixed Guideway
Aerial Structure	$13,295	$10,937
Systems	$86	$236
Site Work & Special Conditions	$2,142	$6,571
ROW	$1,075	$893
Total Project	$30,944	$38,536

Exhibit VI-2
Project Contingency and Soft-Cost Provisions

Contingencies & Soft Costs	Managed Lanes	Fixed Guideway
Guideway, Stations, Yards & Shops, Systems	25%	25%
Site Work & Special Conditions	30%	30%
Project Reserve	6%	6%
ROW	50%	50%
Soft Costs	30%	30%

VII. SUMMARY OF FINDINGS

Key Findings – Top-Down Cost Validation

A key challenge in conducting this cost reasonability analysis was the current lack of specificity in the project's modal definition. Given this lack of specificity, the current project costs were assessed using against the historical, as-built cost experiences of both light and heavy rail projects. Here the costs were compared primarily against prior LRT costs (as Honolulu's cost estimates were developed assuming LRT) but also against HRT costs were appropriate. In general, this latter approach proved most revealing as the project costs exhibit the cost characteristics of both light and heavy rail projects; with some elements having cost characteristics more similar to light rail (e.g., stations and vehicles) and others more similar to heavy rail (most notably aerial structure).

The cost validation analysis determined that the total project cost estimates are reasonable, falling marginally below (roughly $42 million or less than 2%) the expected cost based on recent U.S. light and heavy rail projects. However, this low overall project cost variance is also the product of offsetting positive and negative cost variances across the eight cost categories recognized by the database cost model. Specifically, when the variance analysis is limited to "hard asset" costs alone, including track and structures, facilities, systems, stations, and vehicles, project cost estimates are found to marginally exceed the database predicted costs by roughly $95 million (or roughly 4.5%), again quite reasonable for a pre-PE project. In contrast, the combined project cost estimates for special conditions, ROW, and soft-costs were found to be roughly $135 million, or 10%, lower than expected based on prior project experience as represented in the FTA database. This level of cost variation from the "norm" suggests that these latter three cost categories may benefit from further refinement by Honolulu project staff.

Finally, the provisions for contingencies were found to be adequate and appropriate for a project in the pre-PE phase. Also, the assumed inflation rates used to adjust project costs from $2007 to $YOE were found to be reasonable but not conservative, based on recent cost inflation for construction projects nationally and local Honolulu consumer cost inflation.

Key Findings – Unit Cost Validation

Overall, PBDQ's unit cost estimates for the Honolulu High-Capacity Transit Corridor Project were generally found to be similar to or within acceptable ranges to those derived from other existing sources, and hence should be considered reasonable at this stage of the project. A key exception here is the cost of cast-in-place concrete (a key project input), where the project unit costs appear to be substantially lower than those found using either the RS Means or NAVFAC sources. It is possible that this finding may result from differences in the assumed CIP investment dimensions across these sources. Obtaining local and more recent concrete vendor quotes may help settle this issue.

Other key results included the following:

- Project unit costs, except those associated with cast-in-place (CIP) concrete, were typically greater than their RS Means counterparts, but within an acceptable range of +30%.

- NAVFAC's unit costs were generally greater by 20% to over 150% for some items, when compared to the similar project unit costs. PBQD's listing of unit costs provides only minimal sizing parameters, while the NAVFAC Cost Data Book provides more specificity in terms of sizing, dimensions, and more discrete descriptions of the costs items.

- PBQD's unit costs were generally within the low-high ranges established by recent bids for highway construction in Hawaii.

- Given the recent price volatility in construction materials, current Honolulu market pricing for steel, asphalt, and concrete elements should be obtained to confirm any variances with the respective unit costs used in the PBQD estimate. Sources of such data can include contractor quotations and more current Hawaii DOT bid tabulations.

- Costs for heavy electrical installation/heavy traction power items given in the PBQD estimate could not be compared since no similar items were found in the RS Means, NAVFAC, and Tabulation of Bids reference sources.

Key Findings – Cost Risk Analysis

The cost risk review identified cost elements that either may be missing from the current estimates or which may benefit from further refinement, to reduce cost risk. Following are some of those items that may pose real cost risks to the project and hence which deserve further attention during PE.

<u>Utility Relocation Costs</u>

- <u>Underground Utilities Not Fully Reviewed Since 1991:</u> The last comprehensive utility assessment for buried utilities was performed in 1991 and consisted largely of a review of city utility maps. The current PBQD estimate consists of updated relocation costs applied to the 1991 assessment data. Hence, there is risk that the current cost may be too low, suggesting the need for an updated utility assessment.

- <u>Shared Utility Costs</u>: Private utility relocation costs are assumed to be split 90/10 (project/private). The fact that the utility company bears any cost reduces the incentive perform the relocations promptly, increasing the likelihood the project may bear 100% of the relocation cost in order to maintain schedule.

Stations

- Station Platform Length: The current platform is designed to accommodate three car consists. Honolulu may wish to consider station platforms long enough to accommodate four car consists, to ensure sufficient capacity to meet long-term passenger volumes.

- Park-and-Ride Not Well Defined: The Park-and-Ride and/or Transit Center locations are not well defined in the estimate and hence represent a source of project cost risk. All that is provided are numbers of at-grade or garage parking spaces, or bus bays. The footprint and other attributes of these facilities need to be more clearly defined.

- Stacked Train Station: The stacked station design under consideration for one of the stations in Segment 5 needs to be further refined. Local engineering opinion is that this design may not be feasible and would be very costly to both design and construct.

Constructability

- Constructability Factor of 30% for Segment 5: The current cost estimate for Segment 5 (located in the CBD) contains a 30% factor of to cover the cost of "productivity issues" associated with construction in a dense urban environment. The costs covered by this factor need to be better defined and identified (e.g., traffic protection, access for equipment and material, staging areas, etc.)

Key Findings – Managed Lane Cost Assessment

In response to concerns regarding the estimation procedures for the Managed Lanes alternative (alternative 3) versus those used for the proposed Fixed Guideway investment (alternative 4), the project cost estimates for both of these alternatives were compared to identify any potential cases of analysis bias in favor of one modal alternative over the other. To complete this assessment, the following two comparison activities were completed:

1. Comparison of detailed unit cost assumptions.
2. Comparison of the cost build-up process for the Managed Lanes and Fixed Guideway alternatives.

Based on this analysis, it was determined that both the unit costs and the cost build-up process were exactly the same for both the Managed Lanes and Fixed Guideway alternatives. Moreover, Honolulu project staff verbally confirmed that the unit costs and process for building up the Managed Lanes and Fixed Guideway alternatives were, in fact, exactly the same. Hence, no evidence was found indicating a bias in favor of one modal alternative over the other.